Supplementary Information

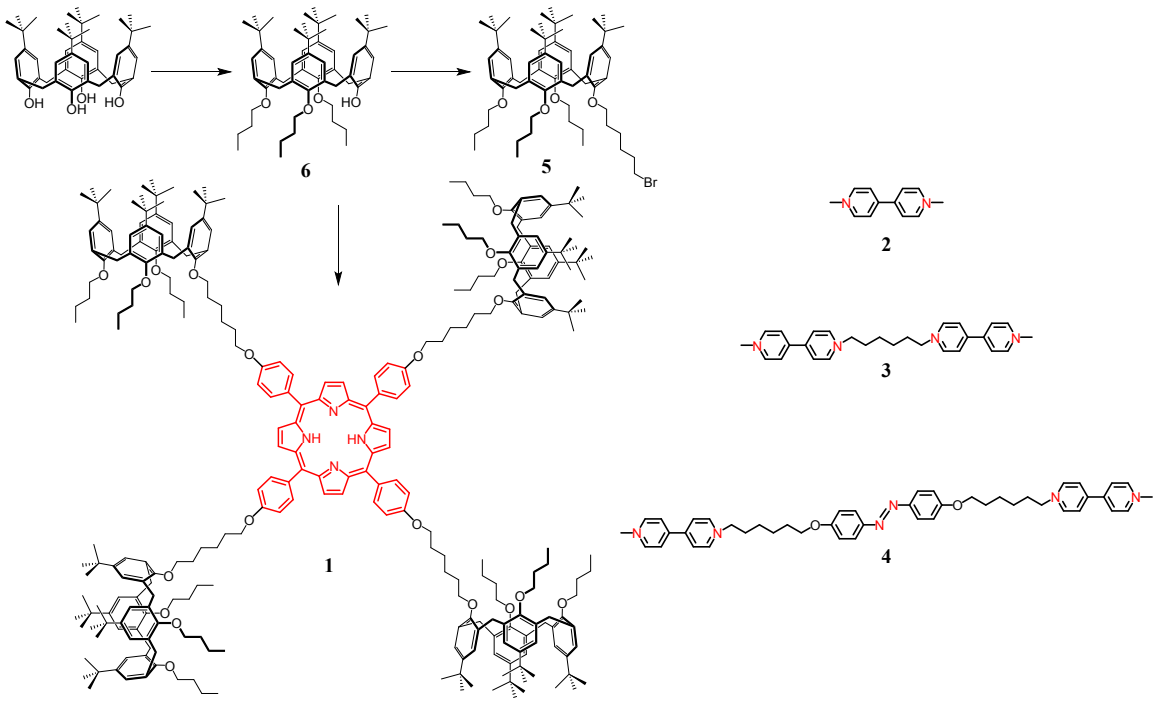
Self-Assembled Supramolecular Nanoparticles Mediated by Host–Guest Interactions for Photodynamic Therapy

Hong Yan, [a] Xiaoyong Pan, [a] Ming Hui Chua, [a] Xiaobai Wang, [a] Jing Song, [a] Qun Ye, [a] Hui Zhou, [a] Angeline TAN Yan Xuan, [a] Ye Liu [a] and Jianwei Xu*[a,b]

[a] *Institute of Materials Research and Engineering (IMRE), Agency for Science, Technology and Research (A*STAR), 3 Research Link, 11760, Republic of Singapore. E-mail: jw-xu@imre.a-star.edu.sg*

[b] *Department of Chemistry, National University of Singapore, 3 Science Drive 3, Singapore 117543, Republic of Singapore*

S1. Additional Experimental Data:



Scheme 1. A schematic illustration for the synthesis of calix[4]arene-containing tetrameric porphyrin derivative and different length of biviologen derivatives.

Synthesis of intermediate compound ***5***: compound **6** (3.1 g, 3.8 mmol), NaH (0.9 g, 38.0 mmol), and 1,6-Dibromohexane (9.3 g, 38.0 mmol) were dissolved/suspended in dry DMF (30 mL) under N_2,

and the mixture solution was stirred at 50 °C overnight. After filtration, the solvent was removed under a reduced pressure. The residue was taken up in H_2O and washed by CH_2Cl_2. After removing the solvent, the residue was purified by column chromatography (CH_2Cl_2 : Hexane = 2 : 1 as eluent) to provide **5** (3.3 g, 88%) as a white solid. ^{1}H NMR (400 MHz, CDCl3, δ): 6.79 (s, 4H, Ar H), 6.76 (s, 4H, Ar H), 4.44 (dd, *J* = 12.4 & 4.6 Hz, 4H; CH_2), 3.85 (m, 8H; CH_2), 3.43 (m, 6H; CH_2), 3.10 (d, *J* = 12.5 Hz, 4H; CH_2), 2.01 (m, 8H; CH_2), 1.09 (m, 6H; CH_2), 1.46 (m, 12H; CH_2), 1.09 (s, 18H; CH_3), 1.07 (m, 18H; CH_3), 1.02 (t, *J* = 7.4 Hz, 9H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, δ): 153.7, 144.2, 133.9, 133.8, 133.7, 124.93, 124.89, 124.83, 75.2, 33.82, 33.80, 33.77, 33.00, 32.44, 32.40, 31.48, 31.46, 31.09, 31.06, 30.1, 28.4, 25.4, 19.4, 14.2; HRMS (ESI, *m/z*): $[M + H]^+$ calcd for $C_{62}H_{92}O_4Br$: 979.6179; found, 979.6182.

*Synthesis of calix[4]arene-containing tetrameric porphyrin derivative **1**:* Compound **5** (1.22 g, 1.25 mmol), 5,10,15,20-Tetrakis(4-hydroxyphenyl)porphyrin **7** (170 mg, 0.25 mmol) and K_2CO_3 (0.69 g, 0.50 mmol) were dissolved/suspended in dry DMF (30 mL) under N_2. And the mixture solution was stirred at 100 °C for 36 hours. After filtration, the solvent was removed under a reduced pressure. The residue was taken up in H_2O and washed by CH_2Cl_2. After removing the solvent, the residue was purified by column chromatography (silica gel, Ethyl acetate : Hexane = 2 : 1 as eluent) to provide **1** (0.14 g, 13%) as a red solid. **1**: ^{1}H NMR (400 MHz, CDCl3, δ): 8.89 (s, 8H, Ar H), 8.14 (d, *J* = 7.5 Hz, 8H, Ar H), 7.39 (d, *J* = 8.3 Hz, 8H, Ar H), 6.88 (s, 16H, Ar H), 6.86 (s, 16H, Ar H), 4.45 (dd, *J* = 12.4 & 1.6 Hz, 16H; CH_2), 3.88 (m, 32H; CH_2), 3.55 (m, 8H; CH_2), 3.15 (d, *J* = 12.4 Hz, 16H; CH_2), 1.95 (m, 40H; CH_2), 1.49 (m, 42H; CH_2), 1.06 (m, 144H; CH_2), 1.04 (m, 36H; CH_3).

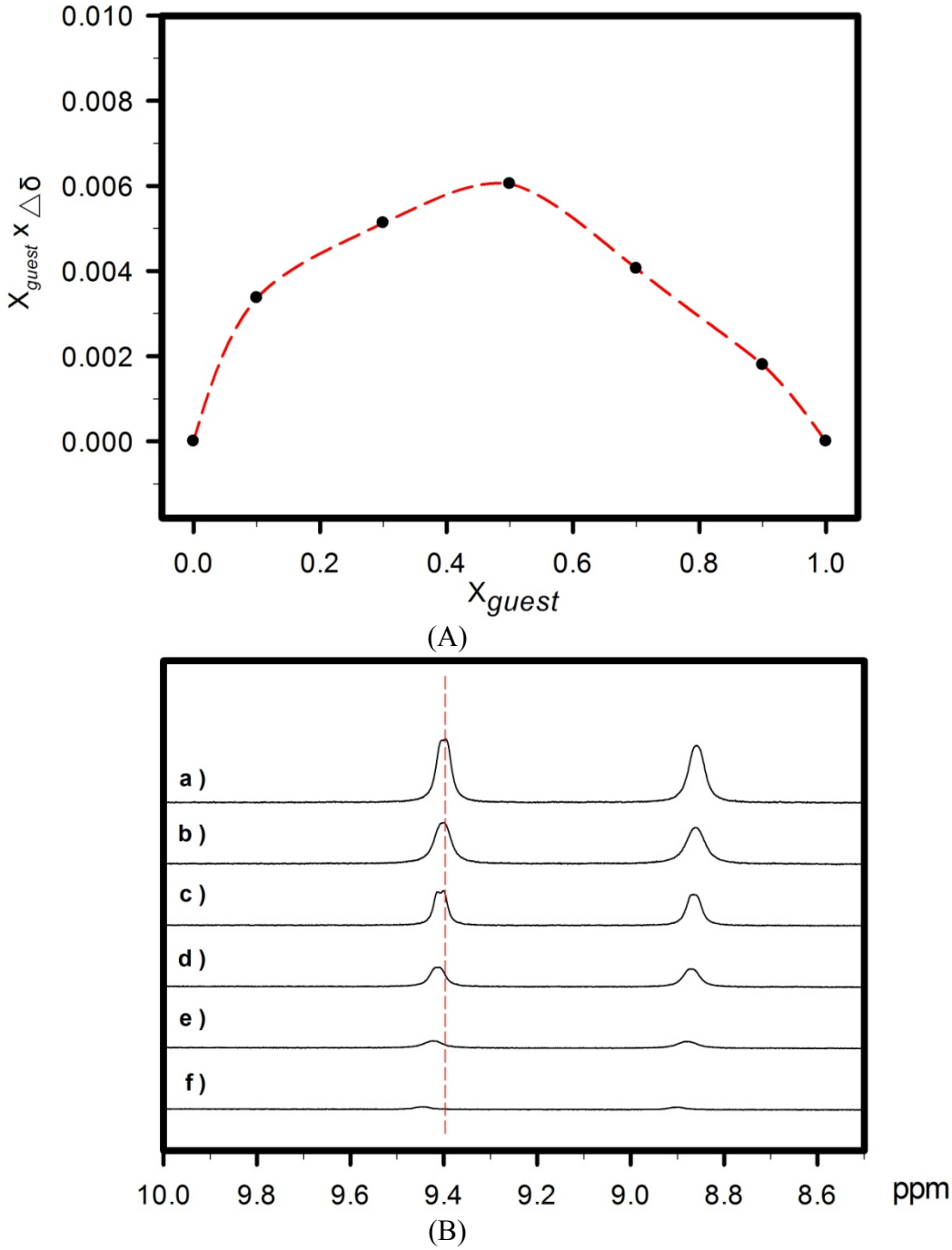


Figure S1. (A) Job plot between mono-calix[4]arene 5 and biviologen derivative 2 collected by plotting the Δδ in chemical shift of the viologen derivatives proton H_a, which was observed by (B) ^{1}H NMR spectroscopy (Acetone-d_6) against the change in the mole fraction of the guest (X_{guest}: a) 100 %; b) 90 %; c) 70 %; d) 50 %; e) 30 %; f) 10 %). [Host] and [Guest] are concentrations of host molecule **5** and viologen derivatives **2**, respectively. The total concentration of host and guest molecules was kept at 20.0 mM in this titration ([Host]+[Guest]=20.0 mM).

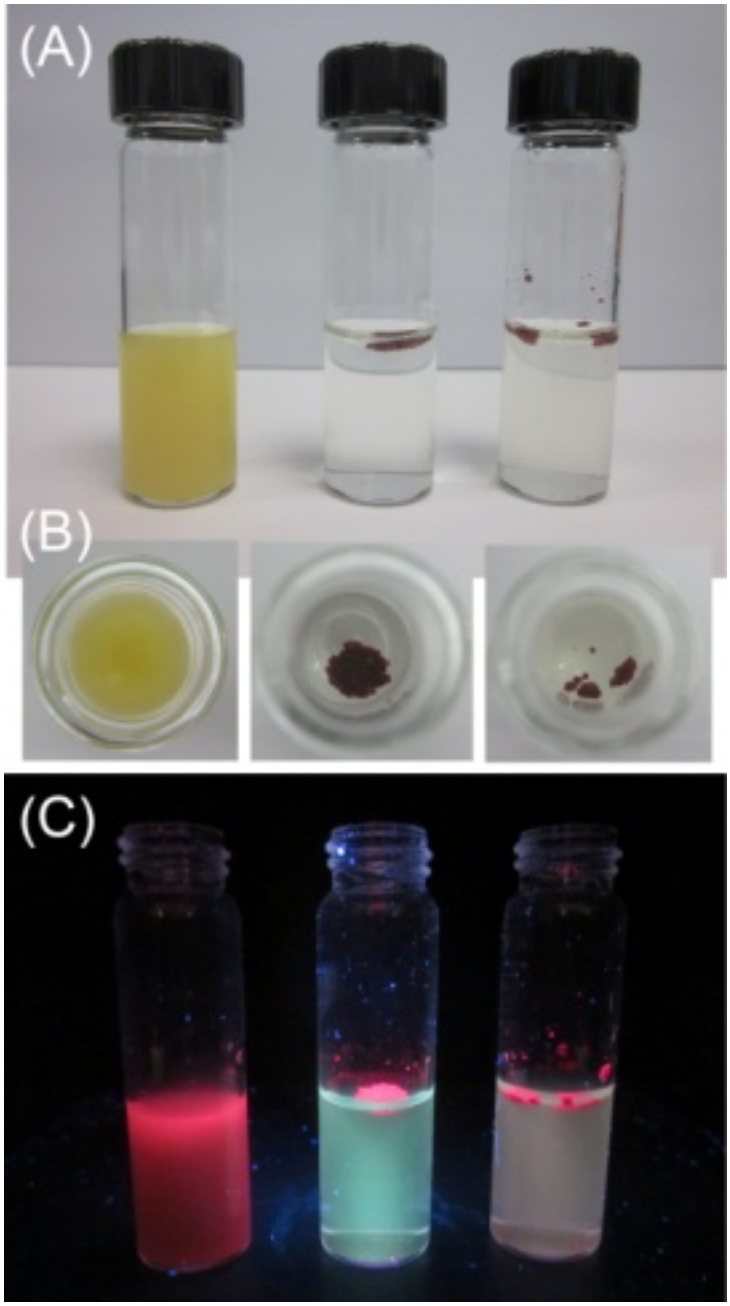


Figure S2. The photographs show visible color (A) and visual fluorescence color (B) changes of the sample solutions after 0.5 mL solution of complextion of host-gust in acetone was then emulsified with 2 mL of water (Right: G1; Middle: G2; Left: G3). The photographs were taken by illuminating the samples with a 365 nm handheld UV lamp.

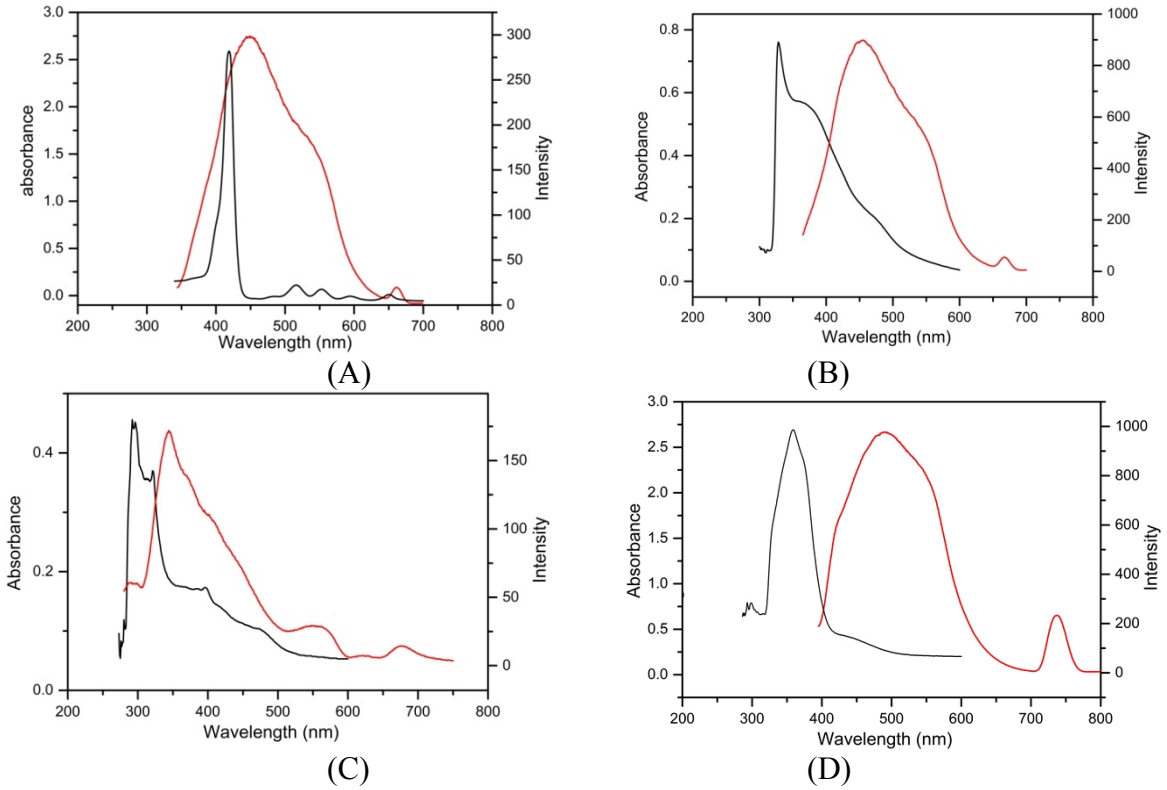


Figure S3. UV-Vis (black line) and fluorescence (red line) spectra of (A) 1, (B) 2, (C) 3 and (D) 4.The photographs show visible color (A) and visual fluorescence color (B) changes of the sample solutions after 0.5 mL solution of complextion of host-gust in acetone was then emulsified with 2 mL of water (Right: G1; Middle: G2; Left: G3).

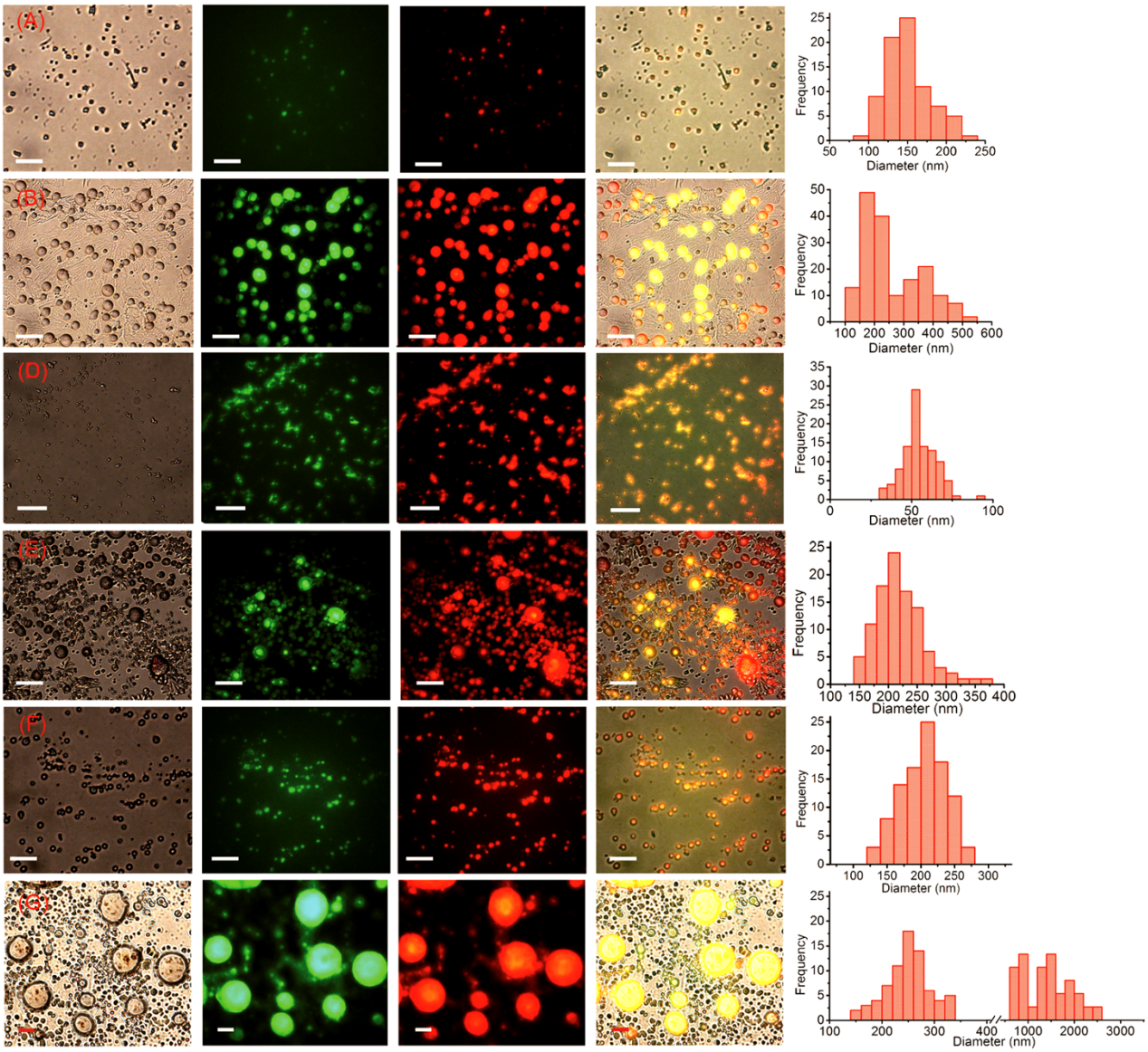


Figure S4. Fluorescence microscopy images of the particulate entities originated by (A) ~ (B) G1, (C) ~ (D) G2 and (E) ~ (F) G3, through method I at total molar concentration 0.2 mM (A, C and E) and 2 mM (B, D and F). Lift to right is bright-field, green channel, red channel, merged layer and particle size distribution. The scale bar is 1 μm.

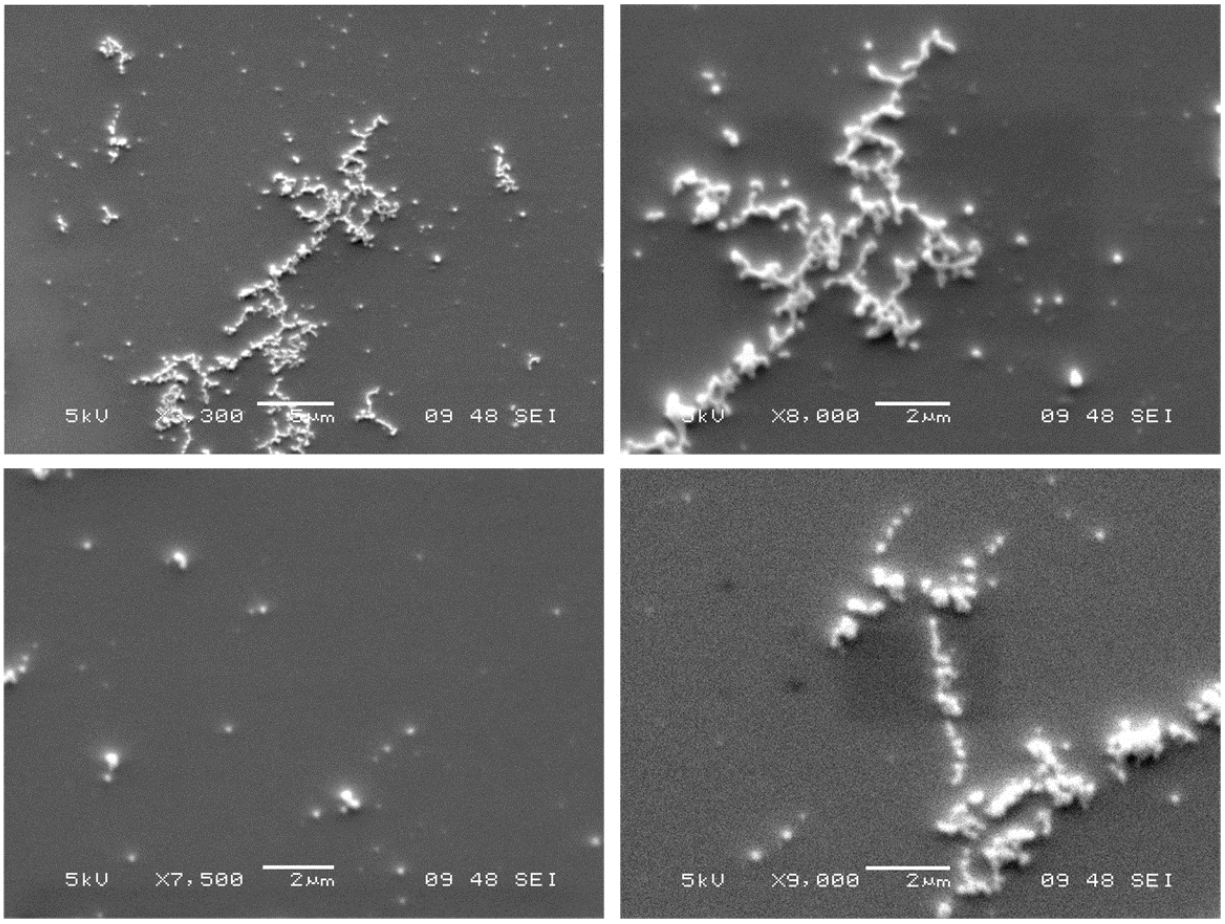


Figure S5. SEM images of the particulate entities originated by G3 through method II at total molar concentration 2 mM.

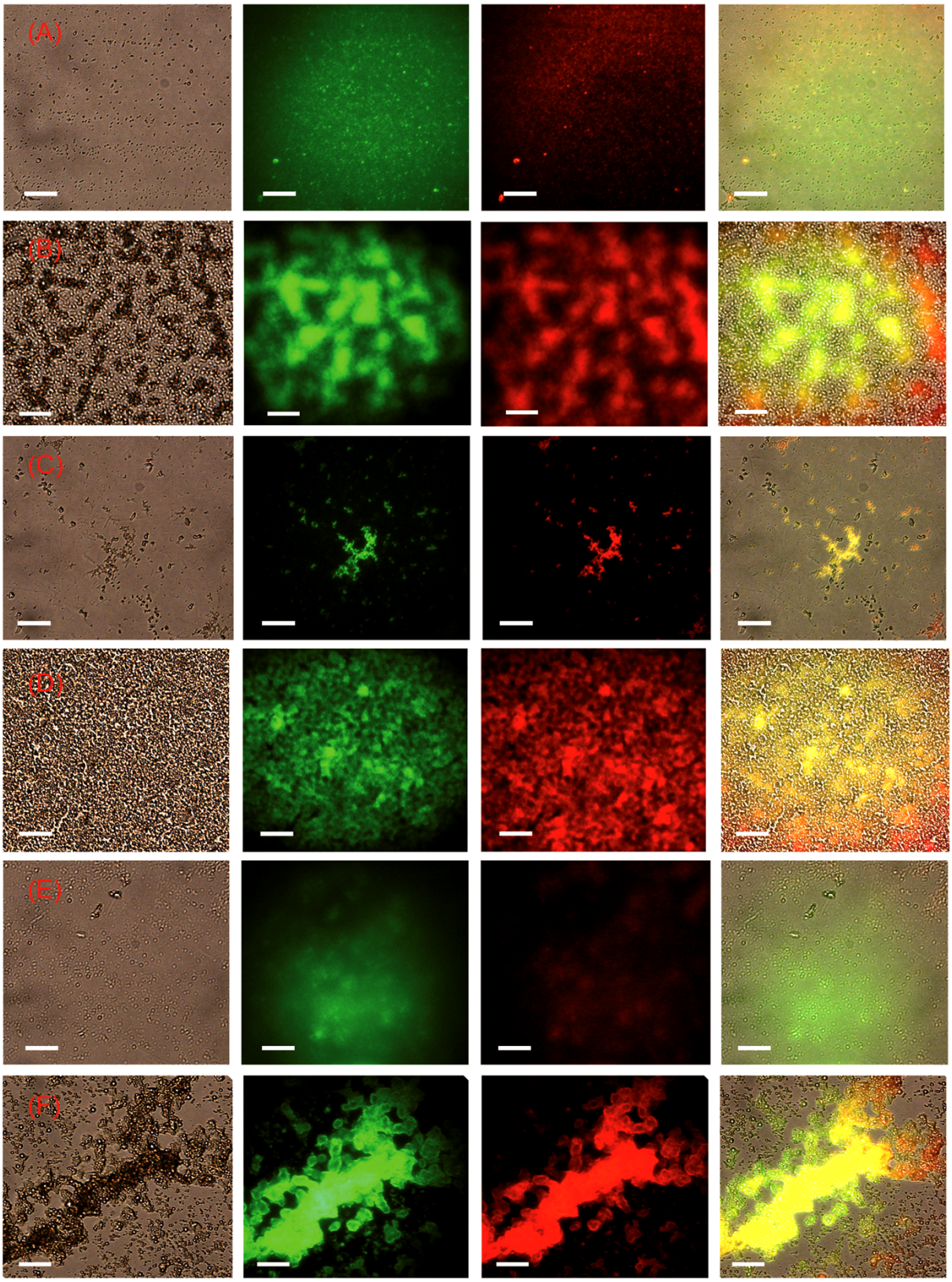


Figure S6. Fluorescence microscopy images of the particulate entities originated by (A) ~ (B) G1, (C) ~ (D) G2 and (E) ~ (F) G3, through method II at total molar concentration 0.2 mM (A, C and E) and 2 mM (B, D and F). Lift to right is bright-field, green channel, red channel, and merged layer. The scale bar is 1 μm.

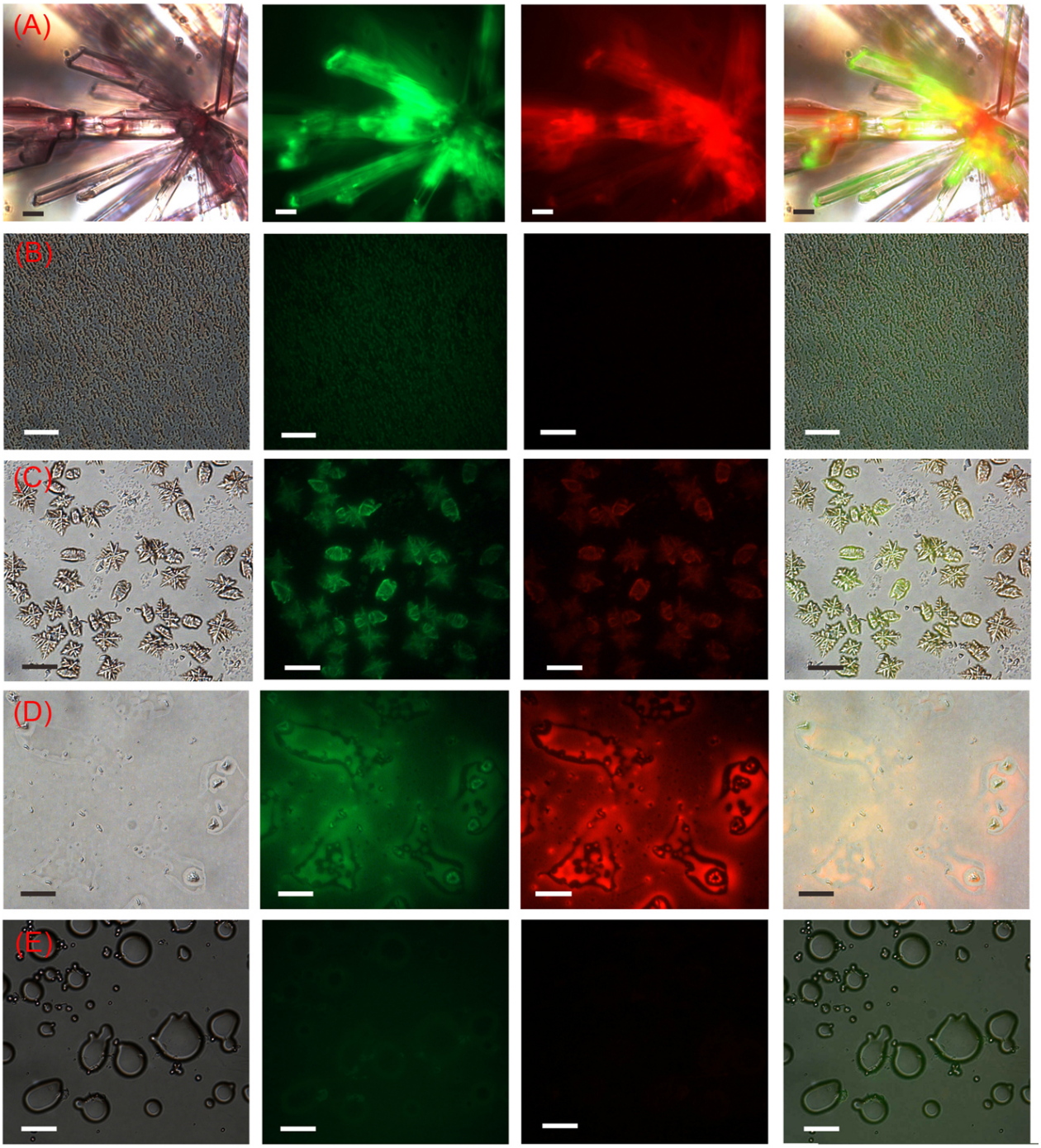


Figure S7. Fluorescence microscopy images of the morphologies originated by drop coating of (A) 1, (B) 2, (C) 3, (D) 4 and 5 on the glass slide at molar concentration 2 mM. Lift to right is bright-field, green channel, red channel, and merged layer. The scale bar is 1 μm.

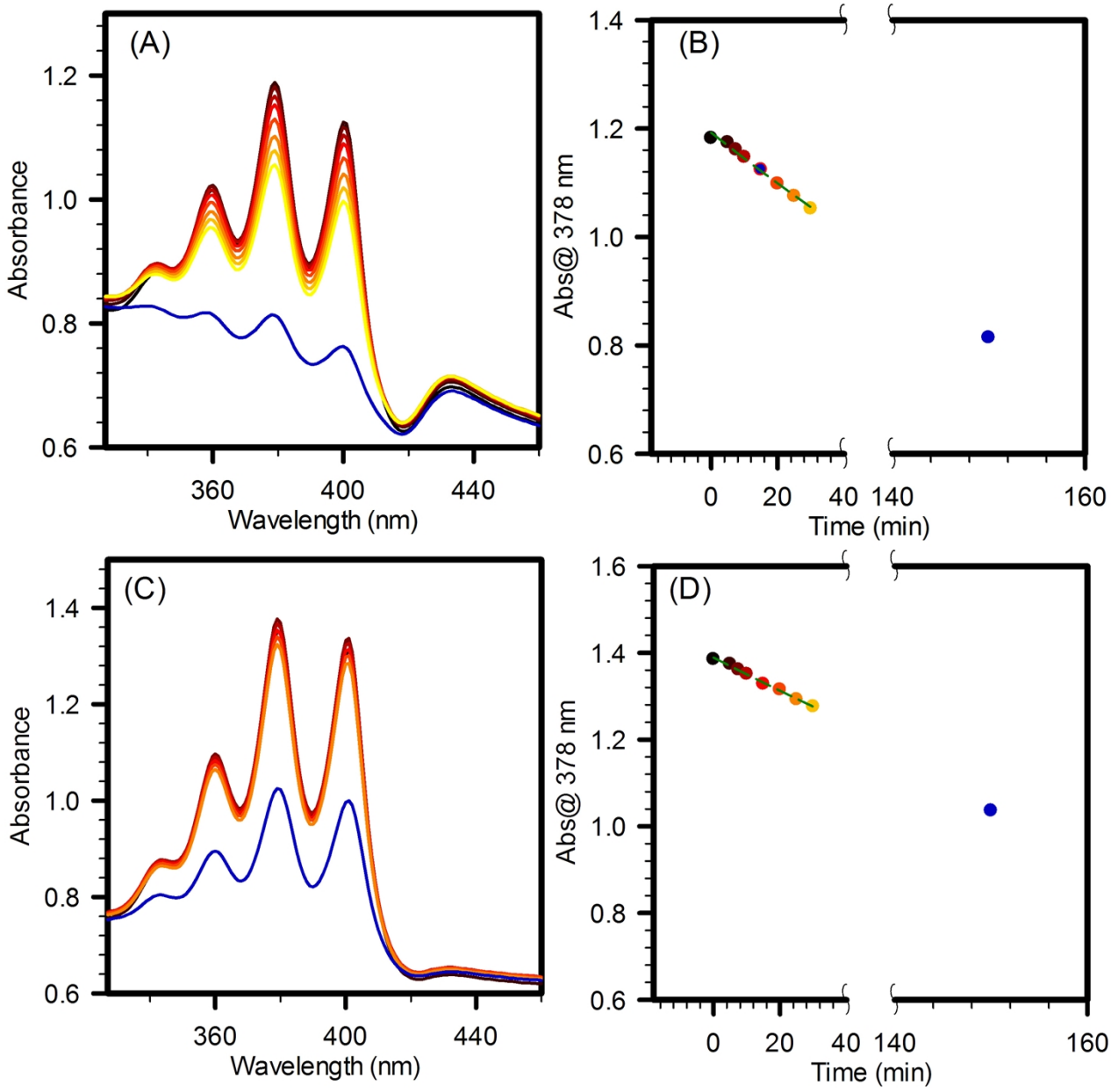
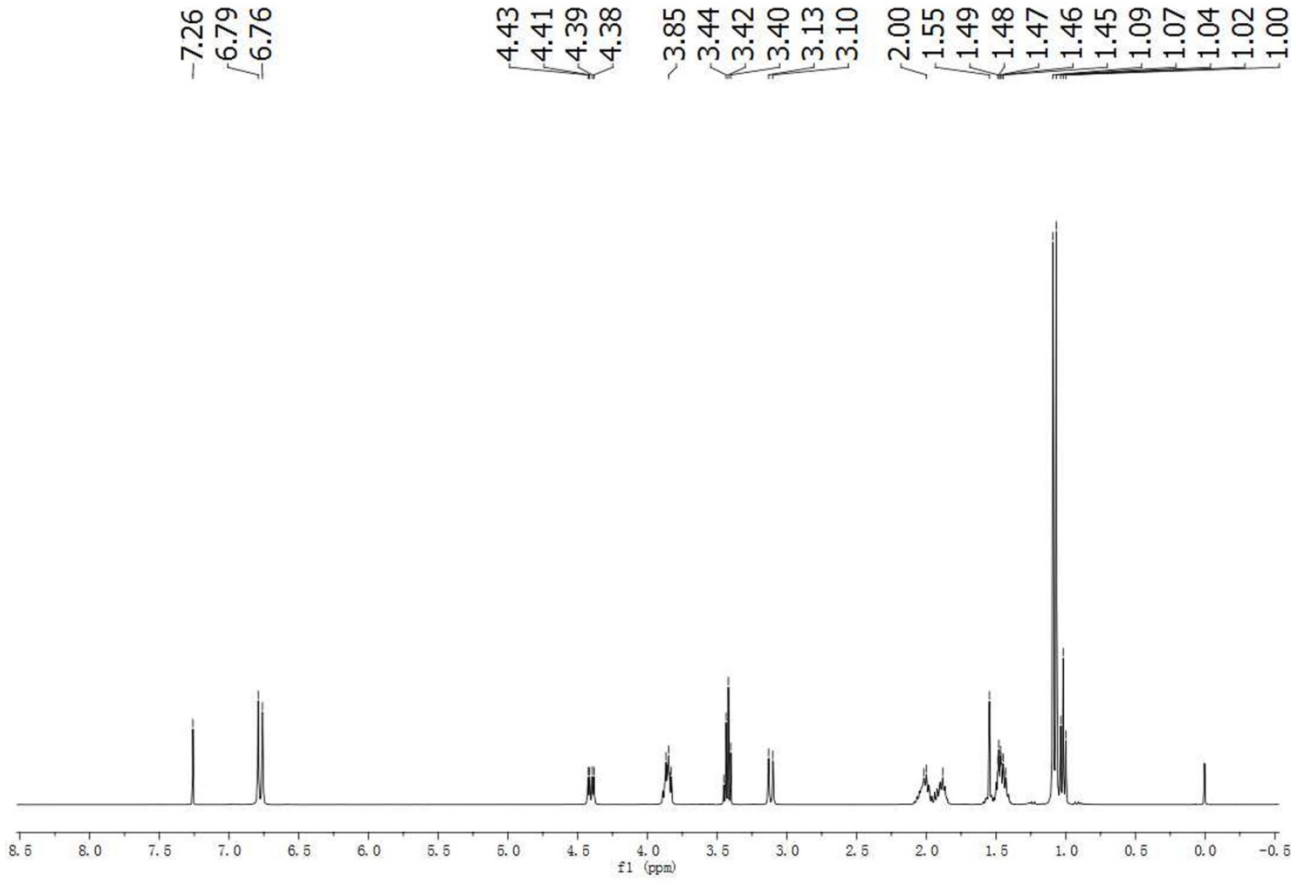


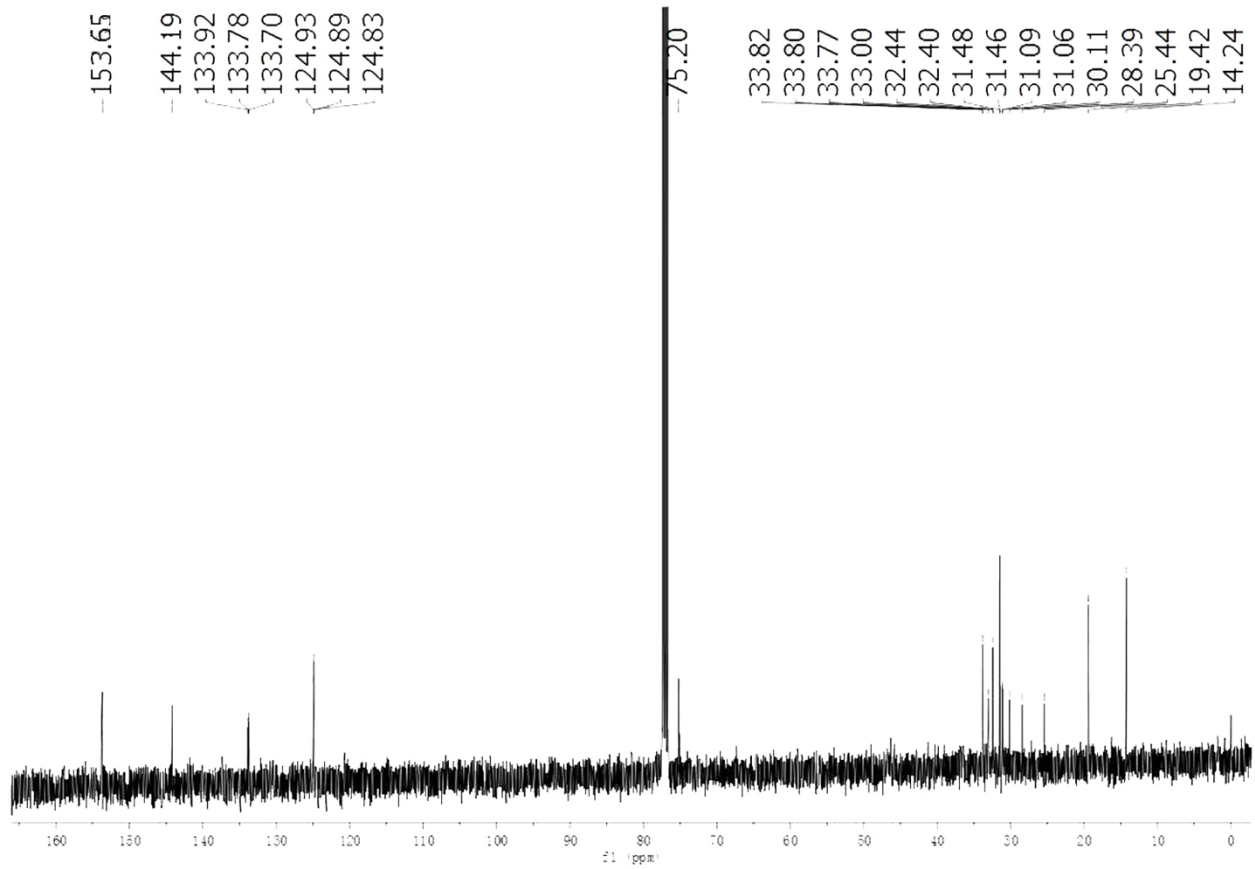
Figure S8. UV-Vis spectral changes of the ABDA in the presence of SNPs (G3) (A) and the same concentration of 5,10,15,20-Tetrakis(4-hydroxyphenyl)porphyrin **7** (C) suspension under illumination by a 633 nm laser for 2.5 h. (B, D) show the absorbance changes at 378 nm.

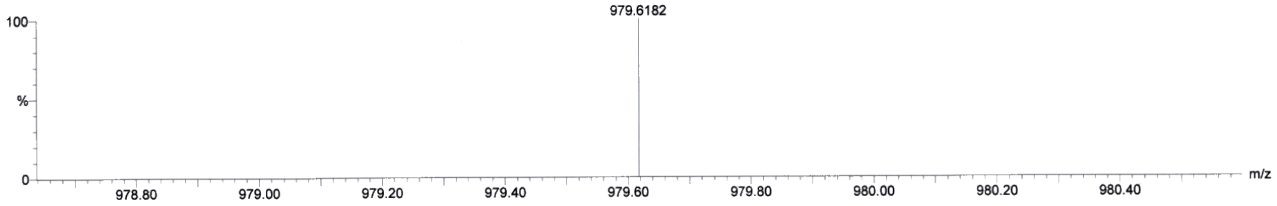
Table S1. Summary of particle sizes observed by dynamic light scattering through method II

	Total Molar Concentration		
	0.2 mM	2 mM	20 mM
G1	163.3 ± 75 nm	150 ± 66.1 nm	186.2 ± 76.7 nm
G2	170.9 ± 77.7 nm	188.0 ± 81.1 nm	195.7 ± 98 nm
G3	115.4 ± 45.5 nm	280.7 ± 67.5 nm	376.4 ± 97.8 nm

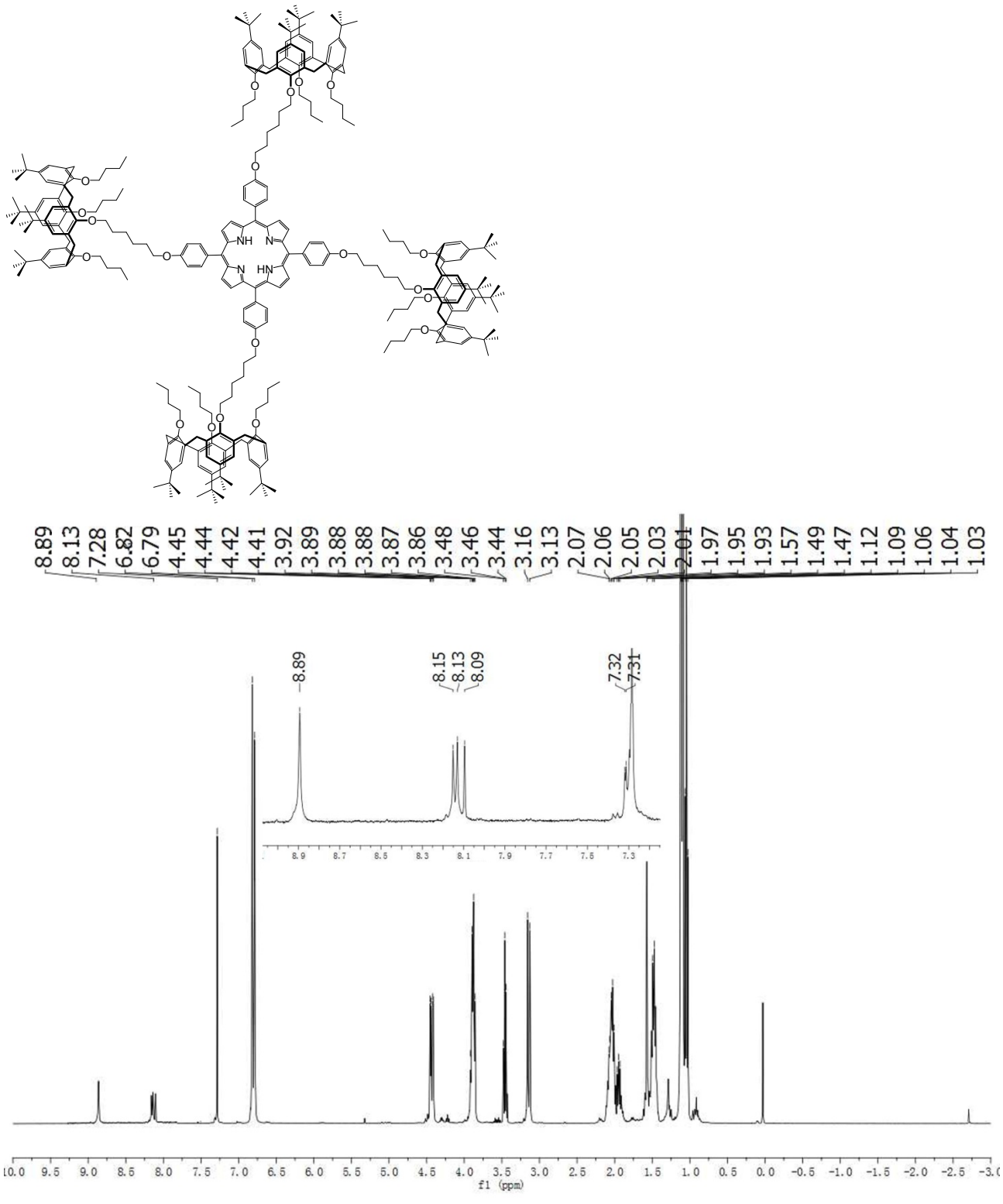
S4. Characterization Spectra (^{1}H and ^{13}C NMR and MS) of Compounds

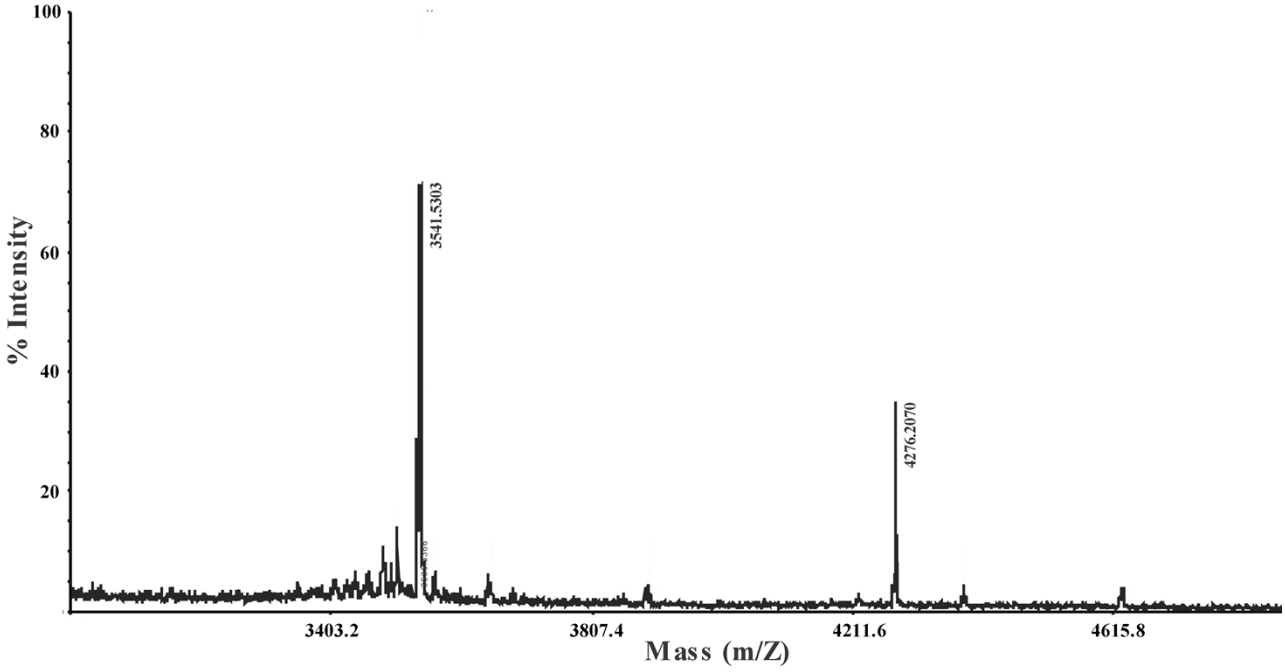






Minimum:				-1.5			
Maximum:		5.0	5.0	100.0			
Mass	Calc. Mass	mDa	PPM	DBE	i-FIT	i-FIT (Norm)	Formula
979.6182	979.6179	0.3	0.3	16.5	22.4	0.0	C62 H92 O4 79Br


8.89
8.13
7.28
6.82
6.79
4.45
4.44
4.42
4.41
3.92
3.89
3.88
3.88
3.87
3.86
3.48
3.46
3.44
3.16
3.13
2.07
2.06
2.05
2.03
2.01
1.97
1.95
1.93
1.57
1.49
1.47
1.12
1.09
1.06
1.04
1.03
8.89
8.15
8.13
8.09
7.32
7.31
f1 (ppm)


100
80
60
40
20
% Intensity
3541.5303
4276.2070
3403.2
3807.4
4211.6
4615.8
Mass (m/Z)